German-Mexican study of surface microstructure changes under ion irradiation.

Dr. Arturo Garcia-Borquez of the **E**scuela **S**uperior de **F**isica y **M**atematicas (ESFM) – **I**nstituto **P**olitecnico **N**acional (IPN), Dept. Materials Science in Mexico City, Mexico, visited Fraunhofer-**I**nstitut fuer **W**erkstoff und **S**trahltechnik (IWS) in Dresden, Germany, in 2008.

What have you worked on during your visit?

I have used atomic force and scanning electron microscopes, x-ray diffraction and other research instruments for characterizing irradiated surfaces of metallic and ceramic samples in collaboration with Dr S Braun, DP T. Holz and Dr J. Kaspar. A special preparation in cross section for future bulk studies was carried out with a Focus Ion Beam (FIB) by D. Wall (FEI-Co. in Eindhoven, NL).

Why is that important for your research and for progress in nanotechnology?

For my research:
The fine measurements achieved by these techniques made possible, in a relative short period of time, to elucidate nanoscale features at the surface of the sample. These contribute to important progress of my current research in Mexico. Moreover, four graduate students are involved with this thematic.
The study of materials under irradiation has not only a fundamental importance for understanding *the evolution of the microstructure* (in Nickel-Silicon (NiSi) alloys) but also practical applications, e.g., for nuclear fission and fusion reactors (stainless steel and Al_2O_3), aero spatial materials, cancer therapy, etc.

For progress in Nanotechnology:
Many modern analytical techniques use an ion-beam as samples probe. Other techniques use it to cut, polish or modify in anyway materials surfaces. The nanoscale modification of the surface under irradiation or ion implantation creates new properties that could be applied for example in catalysis (Al_2O_3), semiconductors industry, optoelectronic nano-devices, adherence improvements, etc. One needs good background and applied knowledge to understand and to drive such irradiation processes, respectively, which in turn is important for the development of the field of nanotechnology.

Why did you come to this European research centre to do this project?

The beam and surface technological applications at IWS are very important to my current research.

The X-Ray Diffraction in Grazing Incidence (GIXRD) applied to near surface studies and the cross-section Transmission Electron Microscope (TEM) samples preparations by FIB are extremely difficult tasks that actually could be impossible, at this time, to reach in Mexico.

What are the results? How will you disseminate them?

Results:

- Roughness measurements with an Atomic Force Microscope (AFM) before and after irradiation show differences and a different behavior for metallic and ceramic materials. This is important to explain electric and catalytic properties changes, as well as for durability under irradiation.
- GIXRD measurement carried out with a twin mirror arrangement demonstrates that it is possible to obtain information near the surface. For our case, the damage zone under irradiation is about 1.5-2 micrometre (µm) deep and differences were detected between the irradiated zone and the non irradiated zone. Improving this method, it could be possible to save time and money without using synchrotron radiation or troublesome cross-section TEM samples preparation. A labour-saving **innovation**.
- Analyses with Scanning Electron Microscope (SEM) and **E**nergy **D**ispersive **X**-ray **S**pectroscopy (EDXS) of irradiated Nickel-Silicon (Ni8%atSi) alloy clearly confirmed the formation of a new phase, rich in silicon, at the grain boundaries that increases with the radiation doses. This phase have to be yet identified by GIXRD or TEM.
- After preparing different kind of samples with a Focused Ion Beam (FIB), Field Emission-**S**canning **T**ransmission **E**lectron **M**icroscopy (FE-STEM) made *in situ*, showed that the radiation damage zone for Ni8%atSi has a 1.5 µm depth and for Al2O3 has 2 µm. With this special preparation, a lot of results will be obtained using FE-TEM, which could be correlated with the other measurements.

Dissemination:

- Fraunhofer IWS lecture on August 28, 2008.
- National Microscopy Congress (IX Congreso Nacional de la Asociación Mexicana de Microscopía. Guanajuato, Mex.; November 9-13th, 2008) participation with two works:
    1. "Control de nanorugosidad en superficies de Si y Al_2O_3 por microscopia de fuerza atomica". A. Garcia-Borquez*, S. Braun#, A. Leson#. Attachment 2.
    2. "Estudio por MEB y MFA de la superficie de Ni8%atSi bajo irradiación de iones de Ni de 3.66 MeV". A. Garcia-Borquez*, J. Kaspar#, S. Braun#, A. Leson#. Attachment 3.

    *ESFM-IPN, Edif. 9, UPALM, 07738 México, D.F.; #Fraunhofer IWS, Winterbergstr. 28, 01277 Dresden, Alemania.

- ESFM-IPN lecture on November 2008: "El uso de electrones y iones en microscopia".

Is this the first contact between both organizations or is your visit part of existing collaboration?

It is the first contact.

What are the plans for future collaboration?

We would like to collaborate on the following topics:

1. GIXRD for surface phase's identification.
2. GIXRD with different incidence angle (0.1-3º) for heterogeneities depth profile determination.
3. Small metallic nanoparticles characterization by SAXS.
4. Roughness measurements with AFM and GIXRD.
5. X-Ray Reflectometry method.

We can contribute with:

1. High resolution SEM measurements.
2. OIM, EPR and PL measurements.
3. RBS measurements.
4. Cross-section lamella TEM preparation by FIB (in one year).

Possible joint developments:

1. Nanoparticles deposition.
2. Upgrade Mexican diffractometers with twin Goebel mirror arrangements.

Do you intend to apply for funding in the EU 7th Framework Programme for RTD?

FONCICYT could have been a good opportunity to submit a collaboration project with EU partners but I received the related information too late. I will apply for funding in the EU 7th Framework Programme.

How may your project in the long term benefit the development of your country or Latin America in general?

Catalytic applications of my project could help against air pollution not only in my country and Latin America, but also for all big cities world wide.

What are your plans for disseminating the results of your visit outside the research community in your country?

- I will present a conference for students on November this year.
- I will present a talk for postgraduate students in December this year.
- I am looking for interested partners and for financial support.

Symbols:

AFM: Atom **F**orce **M**icroscope.
EDXS: **E**nergy **D**ispersive **X**-ray **S**pectroscopy.
EPR: Electron **P**aramagnetic **R**esonance.
FE-STEM: Field **E**mission – STEM.
FIB: Focus **I**on **B**eam.
OIM: Orientation **I**maging **M**icroscopy.
PL: Photo**l**uminescence.
RBS: Rutherford **B**ackscattering **S**pectrometry.

SAXS: Small **A**ngle **X**-ray **S**cattering.
SEM: Scanning **E**lectron **M**icroscopy.
STEM: Scanning **T**ransmission **E**lectron **M**icroscopy.
XRD: X-**R**ay **D**iffraction.

Identification:

Dr. Arturo Garcia-Borquez, materials science, borquez@esfm.ipn.mx
Home organization: **E**scuela **S**uperior de **F**isica y **M**atematicas (ESFM) – **I**nstituto **P**olitecnico **N**acional (IPN), Dept. Materials Science, Mexico City, Mexico, www.esfm.ipn.mx
Host organization: Fraunhofer-**I**nstitut fuer **W**erkstoff und **S**trahltechnik (IWS), Dresden, Germany, www.iws.fraunhofer.de.